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Bone health: Osteoporosis, calcium and vitamin D

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Abstract

Background

Osteoporosis is a bone disease that predisposes to fractures. Sufficient intake of calcium and vitamin D is recommended for prevention and treatment.

Data and methods

Based on 28,406 respondents aged 50 or older to the 2009 Canadian Community Health Survey (CCHS)—Healthy Aging, the population who reported being diagnosed with osteoporosis is profiled. Analysis of calcium and vitamin D intake is based on 10,879 respondents aged 50 or older to the 2004 CCHS—Nutrition. Frequencies, averages and cross-tabulations were produced to estimate the prevalence of diagnosed osteoporosis, dietary intake of calcium and vitamin D, the use of supplements, and total calcium and vitamin D intake. Associations between a diagnosis of osteoporosis and socio-economic, dietary and lifestyle factors were examined with multiple logistic regression.

Results

In 2009, 19.2% of women and 3.4% of men aged 50 or older reported having been diagnosed with osteoporosis; the 2004 rates were similar. Age, sex and household income were associated with the probability of reporting osteoporosis. In 2004, based on dietary and supplement intake, 45% to 69% of the population aged 50 or older had inadequate intake of calcium, and 54% to 66% had inadequate intake of vitamin D.

Interpretation

A large percentage of people aged 50 or older, particularly women, have osteoporosis. The prevalence of inadequate intake of calcium and vitamin D is relatively high.

Keywords

bone density, bone diseases, bone loss, nutrition surveys, 24-hour dietary recall, vitamin and mineral supplements

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The human skeleton is constantly being restored and replaced. In growing children, bone formation exceeds bone loss. The two processes balance out in adulthood, but with advancing age, bone mass starts to decrease.

Osteoporosis is a disease characterized not only by a loss of bone mass, but also by increased bone fragility and risk of fracture.[1] The condition primarily affects older people, particularly women, and is associated with 80% of fractures in people older than age 60. Those fractures can result in reduced quality of life, long hospital stays, institutionalization and higher mortality. The cost is high for the individuals involved and for the health care system.[2]

The prevention and treatment of osteoporosis usually entail special attention to the intake of two nutrients: calcium, which is essential for bone health, and vitamin D, which improves the absorption of calcium.[3-5] Dairy products are the main dietary source of calcium, although it is also found in some fruits, vegetables and grain products. Very few foods provide concentrated Vitamin D. It is added to milk, which is the largest dietary source. The human body also creates vitamin D through sun exposure. Both calcium and vitamin D can be taken in the form of supplements.

This article profiles the population aged 50 or older who reported having been diagnosed with osteoporosis. Variables associated with increased risk of diagnosis and differences between 2004 and 2009 are presented. Intake of calcium and vitamin D from food and from supplements is analyzed by the presence or absence of osteoporosis.

Methods

Data sources

The data are from two Statistics Canada household surveys: the 2004 Canadian Community Health Survey (CCHS)—Nutrition and the 2009 CCHS—Healthy Aging. Both surveys excluded full-time members of the Canadian Forces and residents of the three territories, Indian reserves or Crown lands, selected remote areas, institutions and Canadian Forces bases (military and civilian). Detailed descriptions of the design, sample and interview procedures of the surveys are available in published reports.[6-8]

The 2004 CCHS—Nutrition used a 24-hour dietary recall to estimate food and nutrient intake. A total of 35,107 people completed an initial recall, and a subsample of 10,786 completed a

second recall three to ten days later. The response rates were 76.5% and 72.8%, respectively. To help respondents remember what they ate and drank the previous day, the automated multiple-pass method,[9,10] was used. It consists of five steps:

- a quick list (respondents reported all foods and beverages consumed);
- questions about specific food groups and frequently forgotten foods;
- questions about the type of meal and when it was eaten;
- questions asking for more detail about the foods and beverages and the quantities consumed;
- a final review.

The 2009 CCHS—Healthy Aging had a response rate of 74.4% with a sample of 30,865 people aged 45 or older.

This study is based on data for 10,879 people aged 50 or older who completed the initial 24-hour recall in 2004, and for 28,406 people aged 50 or older who completed the 2009 CCHS.

Calcium and vitamin D requirements

In 2010, the Institute of Medicine released new dietary reference intakes for calcium and vitamin D.[3] For calcium, the estimated average requirement (EAR) for men aged 50 to 70 is 800 mg a day. The EAR is higher—1,000 mg a day—for women aged 50 or older and for men aged 71 or older. The prevalence of inadequate intake can be estimated using the EAR as a cut-point. At age 50 or older, the tolerable upper intake level (UL), above which the potential of adverse effects exists, is 2,000 mg a day.

The EAR for vitamin D at age 50 or older is 10 µg a day, and the UL is 100 µg a day.

Methods of analysis

On the basis of weighted data from the 2004 and 2009 CCHS, frequencies, averages and cross-tabulations were produced to estimate the prevalence of diagnosed osteoporosis, dietary intake of calcium and vitamin D, the use of supplements, and total calcium and vitamin D intake. Associations between the risk of a diagnosis of osteoporosis and socio-economic, dietary and lifestyle factors were examined with multiple logistic regression.

The percentage of the population below the EAR or exceeding the UL for calcium and vitamin D was determined using the Software for Intake Distribution Estimation (SIDE),[11,12] based on estimates of usual intake from the 24-hour recalls in the 2004 CCHS. To estimate total intake of calcium and vitamin D from both food and supplements, the dietary intake of respondents who did not take supplements was combined with the dietary and supplement intake of respondents who took supplements. This method was explained in a published report.[13]

Confidence intervals were estimated with the bootstrap technique, which takes the complex survey design into account.[14-16] The significance level was set at 0.05.

Definitions

Both the 2004 and the 2009 CCHS determined the presence of *osteoporosis* by asking respondents if a health professional had diagnosed them as having the condition.

The following socio-demographic variables were defined the same way in both surveys: *immigrant status*, *highest level of household education* (less than secondary graduation, secondary graduation, some postsecondary, and postsecondary graduation), and *household income*. Household income was total self-reported household income from all sources in the previous 12 months. The ratio of total household income to the low-income cut-off for the relevant household size and community size was calculated for each household. The ratios were adjusted by dividing them by the highest ratio for all respondents combined. The adjusted ratios were divided into quintiles.

Aboriginal status differed slightly in the two surveys. In 2004, "Aboriginal" was among the choices in the question on cultural and racial origins. In 2009, respondents were asked if they were Aboriginal before the question on cultural and racial origins.

The lifestyle variables—*smoking* (smokers are defined as those who smoke every day or occasionally; former smokers as those who no longer smoke but used to do so daily or occasionally) and *alcohol consumption* in the 12 months before the interview (yes or no)—were the same in both surveys.

In 2004, the frequency of *fruit and vegetable consumption* was measured as the sum of the frequencies with which respondents reported consuming foods in six categories: fruit juice, fruit excluding juice, green salad, potatoes (excluding fries, hash browns and chips), carrots, and other vegetables. In 2009, respondents were asked how many servings of fruits and vegetables they consumed per day in general. This question also contributed to the nutritional risk index.

High nutritional risk, which is specific to the 2009 CCHS—Healthy Aging, is defined as a nutritional risk index of less than 38. The index consists of 10 components measuring weight

Table 1
Percentage diagnosed with osteoporosis, by age group and sex, household population aged 50 or older, Canada excluding territories, 2009

	Total			50 to 70			71 or older		
		95% confidence interval			95% confidence interval			95% confidence interval	
	%	from	to	%	from	to	%	from	to
Total	**11.6**	**11.1**	**12.1**	**8.6**	**8.1**	**9.2**	**20.3**	**19.2**	**21.4**
Men	3.4	2.9	3.9	2.5	2.0	3.0	6.4	5.3	7.5
Women	19.2	18.3	20.2	14.7	13.7	15.8	31.1	29.5	32.7

Source: 2009 Canadian Community Health Survey—Healthy Aging

change in the last six months, appetite, fruit and vegetable consumption, fluid consumption, meals, and meal preparation.

Body mass index (BMI) is weight in kilograms divided by height in metres squared. It is used to classify participants as underweight (BMI less than 18.5 kg/m^2), normal weight (18.5 kg/m^2 to 24.9 kg/m^2), overweight (25 kg/m^2 to 29.9 kg/m^2) or obese (greater than or equal to 30 kg/m^2).[17] In this study, BMI was used only with 2009 data. Weight and height were self-reported.

In 2004, respondents were asked how many days in the previous 30 days they had taken supplements and how many they took on average. In 2009, respondents were specifically asked how often they *took vitamin D or calcium supplements* in the previous month. Respondents were identified as users if they had taken supplements at least once in the past month. More information about these derived variables is available in the survey documentation.[18]

Data about calcium and vitamin D intake from food pertain to 2004; this information was not collected in 2009. The calcium and vitamin D content of food was derived from Health Canada's Canadian Nutrient File (Supplement 2001b).[19] Supplement composition was taken from the September 2003 Drug Product Database (DPD)[20] in the case of drug identification numbers (DINs) listed at the time of data collection, and from the spring 2005 DPD in the case of DINs that were missing or incorrect.

Results

Osteoporosis

In 2009, 19.2% of women and 3.4% of men aged 50 or older reported that they had been diagnosed with osteoporosis by a health professional; at age 71 or older, the percentages were much higher: 31.1% of women and 6.4% of men (Table 1). These figures were unchanged from 2004 (data not shown).

In addition to age and sex, diagnosed osteoporosis was significantly associated with Aboriginal status, low household

Table 2
Adjusted odds ratios relating osteoporosis diagnosis to selected characteristics, household population aged 50 or older, Canada excluding territories, 2009

Characteristic	Adjusted odds ratio	95% confidence interval	
		from	to
Sex			
Men	0.25*	0.21	0.30
Women†	1.00	...	...
Age group			
50 to 70	0.48*	0.42	0.54
71 or older†	1.00	...	...
Aboriginal			
Yes	1.75*	1.14	2.69
No†	1.00	...	...
Immigrant			
Yes	0.92	0.79	1.07
No†	1.00	...	...
Highest level of household education			
Less than secondary graduation	1.01	0.87	1.18
Secondary graduation	0.92	0.76	1.12
Some postsecondary	0.93	0.72	1.21
Postsecondary graduation†	1.00	...	...
Household income quintile			
First (lowest)	2.34*	1.81	3.04
Second	1.97*	1.51	2.57
Third	1.44*	1.08	1.90
Fourth	1.48*	1.12	1.95
Fifth (highest)†	1.00	...	...
Smoker			
Yes	1.02	0.82	1.26
Former	0.94	0.82	1.07
No†	1.00	...	...
Drank alcohol in last 12 months			
Yes	0.83*	0.73	0.94
No†	1.00	...	...
Daily fruit/vegetable consumption			
3 servings or less	1.00	0.87	1.15
4 to 6 servings†	1.00	...	...
7 servings or more	0.85	0.69	1.05
High nutritional risk			
Yes	1.18*	1.03	1.34
No†	1.00	...	...
Body mass index category			
Underweight	1.61*	1.17	2.24
Normal weight†	1.00	...	...
Overweight	0.75*	0.66	0.87
Obese	0.77*	0.65	0.92
Took calcium supplements in last month			
Yes	2.56*	2.19	2.98
No†	1.00	...	...
Took vitamin D supplements in last month			
Yes	1.58*	1.35	1.83
No†	1.00	...	...
Province of residence			
Newfoundland and Labrador	1.04	0.81	1.32
Prince Edward Island	0.82	0.62	1.09
Nova Scotia	0.91	0.72	1.16
New Brunswick	0.88	0.67	1.16
Quebec	0.99	0.84	1.18
Ontario†	1.00	...	...
Manitoba	0.60*	0.47	0.76
Saskatchewan	0.88	0.69	1.11
Alberta	0.96	0.79	1.18
British Columbia	0.96	0.79	1.18

† reference category
* significantly different from estimate for reference category ($p<0.05$)
... not applicable
Source: 2009 Canadian Community Health Survey—Healthy Aging

income, alcohol consumption in the previous 12 months, high nutritional risk, low body mass index and the use of calcium or vitamin D supplements (Table 2). However, for some factors, whether they preceded or followed the diagnosis, or indeed, were a consequence of it, could not be determined. For instance, people who took calcium and vitamin D supplements had significantly high odds of having been diagnosed with osteoporosis. But taking such supplements is a component of osteoporosis treatment, so it is possible that the diagnosis triggered their use. By contrast, low body mass index, a known risk factor, probably predated the diagnosis.

The high odds of having been diagnosed with osteoporosis among members of households in the lowest income quintile largely reflected women aged 50 to 70 (Figure 1). At age 71 or older, the percentage of women with osteoporosis did not differ significantly by household income.

Findings for 2004 provide much the same picture; low household income, Aboriginal descent and underweight were significantly related to having been diagnosed with osteoporosis (data not shown).

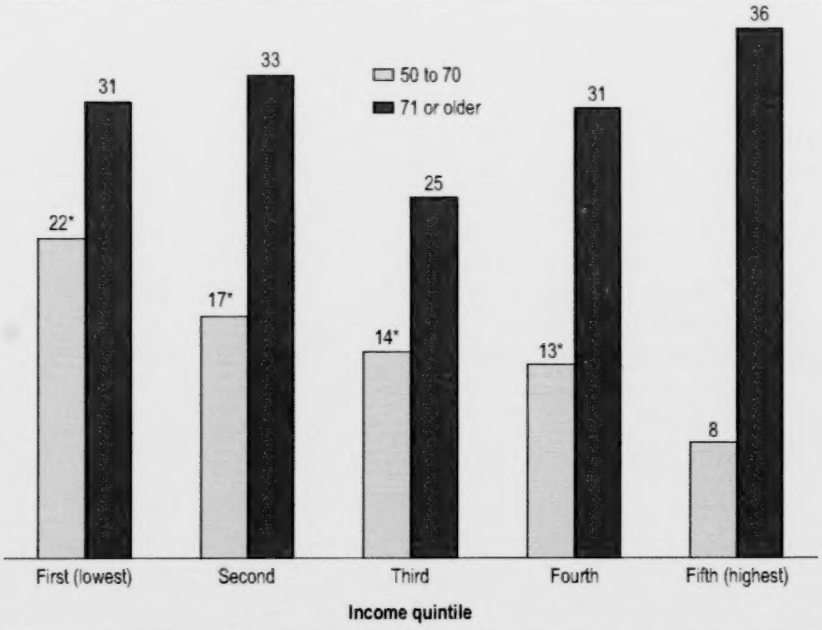
Calcium

In 2004, Canadians older than age 50 obtained an average of 771 mg of calcium a day from what they ate and drank. Milk, cheese, bread, vegetables (except potatoes) and yogurt were the main dietary sources. Based on the dietary reference intakes of the Institute of Medicine, about half of men aged 50 to 70 did not obtain adequate calcium from food alone; for women aged 50 or older and for men aged 71 or older, the percentage with inadequate calcium intake from food was 80% (Table 3).

However, 28% of men and 48% of women aged 50 or older reported taking supplements containing calcium (Table 3). Among those with osteoporosis, the percentages taking calcium supplements were higher—36% of men and 59% of women (data not shown).

Total daily calcium intake from food and supplements combined averaged 969 mg for people aged 50 or older in 2004. Depending on age group and

Figure 1
Percentage diagnosed with osteoporosis, by age group and household income quintile, female household population aged 50 or older, Canada excluding territories, 2009



* significantly different from estimate for fifth quintile (p<0.05)
Source: 2009 Canadian Community Health Survey—Healthy Aging

What is already known on this subject?

- Osteoporosis is characterized by a loss of bone mass and increased bone fragility and risk of fracture.
- The condition primarily affects older people, notably women.
- The prevention and treatment of osteoporosis usually involve sufficient intake of calcium and vitamin D.

What does this study add?

- This study provides recent data on the prevalence of diagnosed osteoporosis and on the use of calcium and vitamin D supplements
- In 2009, 19.2% of women and 3.4% of men aged 50 or older reported that they had been diagnosed with osteoporosis; at age 71 or older, the corresponding percentages were 31.1% and 6.4%.
- According to nutrition data from 2004, 28% of men and 48% of women aged 50 or older took calcium supplements; for those with osteoporosis, the percentages were 36% and 59%.
- An estimated 27% of men and 48% of women took vitamin D supplements; for people with osteoporosis, the percentages were 38% and 57%.
- Even among those who took supplements, at least 25% had inadequate calcium intake, and more than 10% had inadequate vitamin D intake.

Table 3
Calcium and vitamin D intake, by age group and sex, household population aged 50 or older, Canada excluding territories, 2004

	50 to 70						71 or older					
	Men			Women			Men			Women		
		95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval	
	Estimate	from	to	Estimate	from	to	Estimate	from	to	Estimate	from	to
Calcium												
Intake from food only												
Average (mg)	824	793	856	751	725	776	774	711	837	689	659	719
% below EAR	53.2	48.5	57.8	81.5	78.5	84.6	79.2	73.2	83.7	86.4	83.2	89.6
% consuming supplements containing calcium	28.3	25.7	31.0	49.0	46.3	51.7	27.2	23.4	31.0	45.9	42.6	49.2
Combined intake from food and supplements												
Total population												
Average (mg)	913	879	947	1,058	1,020	1,096	891	812	970	947	908	986
% below EAR	44.5	40.0	49.0	56.8	53.5	60.1	69.4	63.5	75.3	63.1	59.2	67.0
Supplement users only												
Average (mg)	1,135	1,059	1,211	1,417	1,360	1,475	1,268	1,098	1,438	1,274	1,217	1,331
% below EAR	24.9	17.1	32.7	26.9	23.2	30.6	40.0	27.3	52.7	33.3	27.8	38.8
% above UL	5.7[E]	2.8	8.6	16.2	13.1	19.3	F	.	.	9.9	7.2	12.6
Vitamin D												
Intake from food only												
Average (µg)	6.8	6.0	7.6	4.9	4.5	5.4	6.6	5.7	7.4	5.9	4.6	7.1
% below EAR	80.0	73.9	86.4	91.5	87.3	95.9	86.0	79.6	91.4	87.8	78.9	95.3
% consuming supplements containing vitamin D	27.2	24.5	29.8	45.0	42.2	47.7	28.5	24.6	32.5	43.0	39.8	46.1
Combined intake from food and supplements												
Total population												
Average (µg)	9.5	8.6	10.4	10.2	9.5	10.9	10.1	9.0	11.2	11.0	9.7	12.4
% below EAR	64.9	60.2	69.6	57.6	53.1	62.2	66.3	60.4	72.1	54.3	46.6	61.9
Supplement users only												
Average (µg)	18.2	15.8	20.6	16.7	15.8	17.6	19.4	17.2	21.6	17.3	16.3	18.4
% below EAR	15.0[E]	7.7	22.3	16.7	13.2	20.2	11.8[E]	5.5	18.1	14.4	10.5	18.3

[E] use with caution
F too unreliable to be published
. . not applicable
Notes: EAR: estimated average requirement; UL: Tolerable Upper Intake Level threshold; Calcium: EAR=800 mg for men aged 50 to 70, 1,000 mg for men aged 71 or older and women aged 50 or older; UL=2,000 mg. Vitamin D: EAR=10µg.
Source: 2004 Canadian Community Health Survey—Nutrition.

sex, 45% to 70% had inadequate intake (Table 3). The average total calcium intake of those who took supplements was 1,303 mg, 515 mg of which came from supplements. Even so, 25% to 40% of them had inadequate total intake. On the other hand, a substantial share of supplement users, particularly women, consumed more calcium than the tolerable upper intake level threshold of 2,000 mg (Table 3).

The amount of calcium obtained from food and beverages did not differ significantly between people who had and had not been diagnosed with osteoporosis (Figure 2). However, those with osteoporosis derived more calcium from supplements, which resulted in significantly higher total intake, compared with people who did not have osteoporosis.

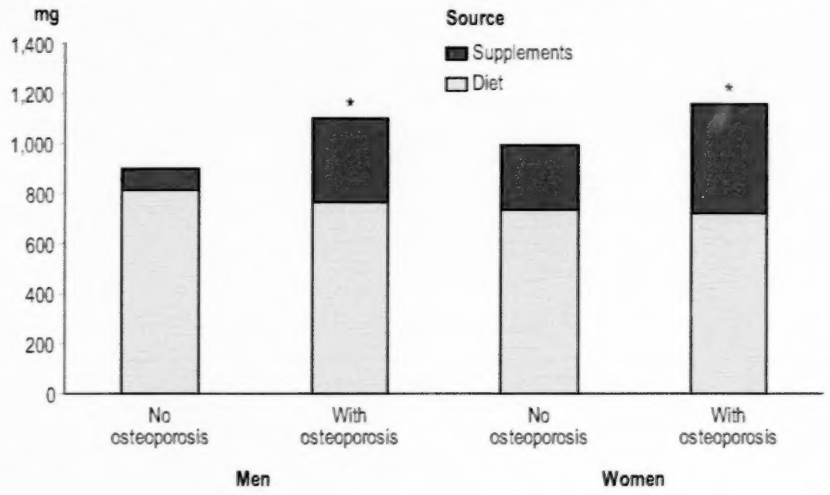
Vitamin D

Milk, fish, margarine, eggs and beef are the main dietary sources of vitamin D. In 2004, the food and beverages that Canadians aged 50 or older consumed gave them an average of 5.9 µg of vitamin D a day, well below the Institute of Medicine's EAR of 10 µg. Based on diet alone, more than 80% of people in this age range were below the EAR.

In 2004, 27% of men and 44% of women took vitamin D supplements (Table 3). For people with osteoporosis, the percentage using vitamin D supplements was 38% among men and 57% among women (data not shown).

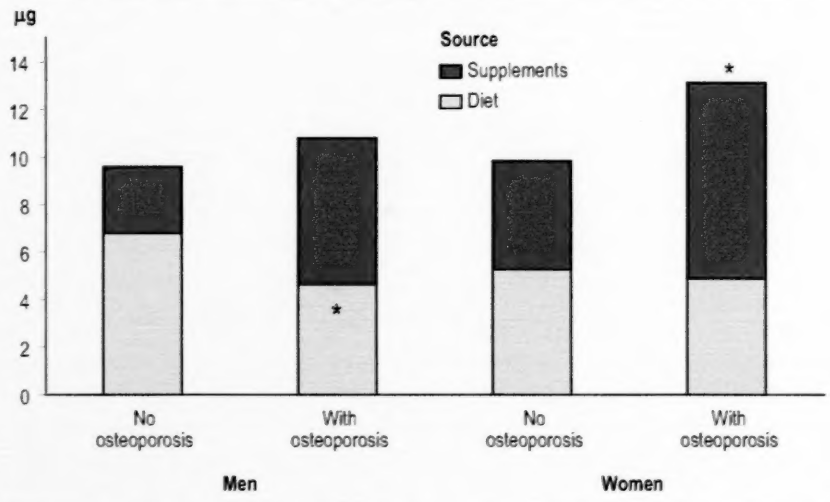
At age 50 or older, total daily vitamin D intake from diet and supplements combined averaged 10 µg. However, 54% to 66% of people in this age range were below the EAR. For supplement users alone, total vitamin D intake averaged 17.5 µg a day, 11.3 µg of which came from supplements; 12% to 17% of this population were below the EAR (Table 3). Fewer than 1% of people aged

Figure 2
Average daily calcium consumption, by source, osteoporosis diagnosis and sex, household population aged 50 or older, Canada excluding territories, 2004



* significantly different from estimate for no osteoporosis ($p<0.05$)
Source: 2004 Canadian Community Health Survey—Nutrition.

Figure 3
Average daily vitamin D consumption, by source, osteoporosis diagnosis and sex, household population aged 50 or older, Canada excluding territories, 2004



* significantly different from estimate for no osteoporosis ($p<0.05$)
Source: 2004 Canadian Community Health Survey—Nutrition.

50 or older had vitamin D intake above the tolerable upper intake level of 100 µg (data not shown).

Men diagnosed with osteoporosis obtained less vitamin D from their diets than did men who did not have the condition; when supplements were included, total vitamin D intake did not differ between men who did and did not have osteoporosis (Figure 3). Among women, vitamin D intake from food and beverages was similar whether or not they had osteoporosis. However, when supplements were included, women with osteoporosis had significantly higher total vitamin D intake.

Discussion

The self-reported prevalence of diagnosed osteoporosis and the characteristics associated with it did not change between 2004 and 2009. Many of the characteristics identified in this study have been observed previously or are established risk factors. Low BMI, for example, is a well-documented risk factor for fractures[21] and osteoporosis.[22] The nutritional risk variable used in this analysis is based, in part, on weight loss, which is also associated with fractures and osteoporosis.[23-25] As well, higher fracture risks for Aboriginal Canadians have been reported.[26]

Clinical practice guidelines recommend that those with osteoporosis consume sufficient calcium and vitamin D.[27] Therefore, it is no surprise that in this study, people with the condition were more likely than those without it to have taken supplements and to have derived larger amounts of calcium and vitamin D from supplements. In fact, those with osteoporosis had the same dietary calcium intake as people without the condition. Moreover, men with osteoporosis actually obtained less vitamin D from dietary sources alone. Taking supplements offset the difference in vitamin D intake among men and gave those with osteoporosis an advantage in calcium intake.

The link between osteoporosis and household income has received relatively

little attention, and the results of the research that has been conducted are not definitive. A comprehensive review of articles published between 1966 and 2007 on the association between socio-economic status and osteoporosis fracture uncovered only three studies that found a higher risk of fracture in lower-income people.[28] A study of American women older than age 50 reported no correlation between osteoporosis diagnosis and household income.[29] By contrast, an association between low bone density and low income has been reported,[30] and according to a Canadian study,[26] fracture risks were higher among low-income people. However, because these studies were cross-sectional, the osteoporosis diagnosis itself may have affected household income—for example, by restricting the ability to work. Supplementary analyses of the 2004 CCHS data showed a significant correlation between household income and supplement use, but not between household income and total intake of calcium or vitamin D (data not shown).

Measured concentrations of vitamin D in the blood (25-hydroxyvitamin D [25(OH)D]) and reported vitamin D intake differed. According to recent data from the 2007 to 2009 Canadian Health Measures Survey, an estimated 22% of 50- to 79-year-olds had measured blood concentrations below 50 nmol/L, the level targeted by the EAR.[3] However, results from the 2004 CCHS show that the prevalence of inadequate vitamin D intake was around 60%. Sun exposure might account for this difference, because the EAR assumes that it is minimal. Underreporting of intake is another possible explanation.

Limitations

The main limitation of this study is that it is based on cross-sectional data. Characteristics in childhood or even before birth may affect the risks of developing osteoporosis in adulthood.[31] Such longitudinal factors could not be taken into account.

In addition, the osteoporosis diagnosis is self-reported, and therefore, prevalence is likely underestimated because some people who have the condition may not have been diagnosed.

Nutrition surveys are subject to underreporting of energy intake, and by extension, of the intake of nutrients such as calcium and vitamin D. Earlier studies of the collection instrument used by the CCHS estimated average energy underreporting at 10%[32] or 11%.[33]

No nutritional data for calcium and vitamin D were available for 2009. The 2004 data on dietary and supplement intake are the most recent and comprehensive available.

Conclusion

According to the 2009 CCHS—Healthy Aging, 3% of men and 19% of women aged 50 or older reported having been diagnosed with osteoporosis. A diagnosis of osteoporosis was significantly associated with age, sex, Aboriginal origin, high nutritional risk and underweight. The odds were also high for people in lower-income households, notably women aged 50 to 70.

Physicians often recommend increased calcium and vitamin D consumption for people with osteoporosis. And in fact, those with osteoporosis were more likely to take supplements, and so had higher total calcium and vitamin D intake than did people who did not have the condition. Yet household income was not significantly related to the total intake of calcium and vitamin D. While sufficient calcium and vitamin D are required to promote bone health, other nutrients are also involved.[34] As well, smoking and excessive sodium, caffeine and alcohol consumption can increase the risk of osteoporosis,[35] and a balanced diet and physical activity, especially weight-bearing exercises, can reduce it. More detailed studies might provide a clearer understanding of the associations between osteoporosis and demographic, socio-economic, dietary and lifestyle factors. ■

References

1. World Health Organization. *Assessment of Fracture Risk and Its Application to Screening for Postmenopausal Osteoporosis* (WHO Technical Report Series, No. 843) Geneva: World Health Organization, 1994.
2. Osteoporosis Canada. *Breaking Barriers Not Bones; 2008 National Report Card on Osteoporosis Care*. Toronto: Osteoporosis Canada, 2008.
3. Institute of Medicine. *Dietary Reference Intakes for Calcium and Vitamin D*. Washington DC: National Academy Press, 2010.
4. U.S. Department of Health and Human Services. *The 2004 Surgeon General's Report on Bone Health and Osteoporosis: What It Means To You*. Place of publication: U.S. Department of Health and Human Services, Office of the Surgeon General, 2004
5. Health Canada. *It's Your Health - Seniors and Aging - Osteoporosis*. Available at: http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/diseases-maladies/seniors-aines-ost-eng.php. Accessed July 5, 2010.
6. Béland Y, Dale, Dufour J, Hamel M. The Canadian Community Health Survey: Building on the success from the past. *Proceedings of the American Statistical Association Joint Statistical Meeting, Section on Survey Research Method, August, 2005*. Minneapolis, Minnesota: American Statistical Association, 2005.
7. Statistics Canada. *Canadian Community Health Survey (CCHS): Cycle 2.2, Nutrition: General Health Component Including Vitamin and Mineral Supplements, and 24-hour Dietary Recall Component, User Guide, 2008*. Available at: http://www.statcan.gc.ca/imdb-bmdi/document/5049_D24_T9_V1-eng.pdf..
8. Statistics Canada. *Canadian Community Health Survey (CCHS) – Healthy Aging – 2008/2009, User Guide*. Ottawa: Statistics Canada, 2008.
9. Moshfegh AJ, Borrud L,Perloff B, et al. Improved method for the 24-hour dietary recall for use in national surveys . *The FASEB Journal: Official Publication of The Federation of American Societies for Experimental Biology* 1999; 13: A603 (Abstract).
10. Moshfegh AJ, Raper N, Ingwersen L, et al. An improved approach to 24-hour dietary recall methodology. *Annals of Nutrition and Metabolism* 2001; 45(suppl): 156 (abstract).
11. Nusser SM, Carriquiry AL, Dodd KW, et al. A semiparametric transformation approach to estimating usual daily intake distributions. *Journal of the American Statistical Association* 1996; 91(436): 1440-9.
12. Novenario MJ. *User's Guide to SIDE, A, August 1996*. Available at: http://www.card.iastate.edu/publications/DBS/PDFFiles/96tr32.pdf. Accessed December 12, 2010.
13. Garriguet D. Combining nutrient intake from food and from vitamin and mineral supplements. *Health Reports* 2010; 21(4): 71-84.
14. Rao JNK, Wu CFJ, Yue K. Some recent work on resampling methods for complex surveys. *Survey Methodology* (Statistics Canada, Catalogue 12-001) 1992; 18(2): 209-17.
15. Rust KF, Rao JNK. Variance estimation for complex surveys using replication techniques. *Statistical Methods in Medical Research* 1996; 5: 281-310.
16. Yeo D, Mantel H, Liu TP. Bootstrap variance estimation for the National Population Health Survey. *Proceedings of the Annual Meeting of the American Statistical Association: Survey Research Methods Section, August 1999*. Baltimore, Maryland: American Statistical Association, 1999.
17. World Health Organization. *Obesity: Preventing and Managing the Global Epidemic* (WHO Technical Report Series, No. 894) Geneva: World Health Organization, 2000.
18. Statistics Canada. *Canadian Community Health Survey (CCHS): Cycle 2.2, Nutrition: General Health Component Including Vitamin and Mineral Supplements, and 24-hour Dietary Recall Component, Derived Variables Documentation*, 2008.
19. Health Canada. 2005. *Canadian Nutrient File, 2005 Version*. Available at: http://www.hc-sc.gc.ca/fnan/nutrition/fiche-nutri-data/index_e.html.
20. Health Canada. *Drug Product Database*. Available at: http://www.hc-sc.gc.ca/dhp-mps/prodpharma/databasdon/index-eng.php.
21. De Laet C, Kanis JA, Odén A, et al. Body mass index as predictor of fracture risk: A meta-analysis. *Osteoporosis International*, 2005; 16: 1330-8.
22. Morin S, Tsang JF, Leslie WD. Weight and body mass index predict bone mineral density and fractures in women aged 40 to 59 years. *Osteoporosis International* 2009; 20: 363-70.
23. Meyer HE, Tverdal A, Selmer R. Weight variability, weight change and the incidence of hip fracture: a prospective study of 39,000 middle-aged Norwegians. *Osteoporosis International* 1998; 8: 373-8.
24. Ricci TA, Chowdhury HA, Heymsfield SB,et al. Calcium supplementation suppresses bone turnover during weight reduction in postmenopausal women. *Journal of Bone and Mineral Research* 1998; 13: 1045-50.
25. Compston JE, Laskey MA, Croucher PI, et al. Effect of diet-induced weight loss on total body bone mass. *Clinical Science* 1992; 82: 429-32.
26. Leslie WD, Derksen AA, Metge C, et al. Demographic risk factors for fracture in First Nations people. *Canadian Journal of Public Health* 2005; 96(S1): S45-50.
27. Boonen S, Rizzoli R, Meunier PJ, et al. The need for clinical guidance in the use of calcium and vitamin D in the management of osteoporosis: a consensus report. *Osteoporosis International* 2004; 15: 511-9.
28. Brennan SL, Pasco JA, Urquhart DM, et al. The association between socioeconomic status and osteoporosis fracture in population-based adults: a systematic review. *Osteoporosis International* 2009; 20: 1487-97
29. Gallagher CM, Kovach JS, Meliker JR. Urinary cadmium and osteoporosis in U.S. women ≥ 50 years of age: NHANES 1988-1994 and 1999-2004. *Environmental Health Perspectives* 2008; 116(10): 1338–43.
30. Wang M-C, Dixon LB. Socioeconomic influences on bone health in postmenopausal women: findings from NHANES III, 1988-1994. *Osteoporosis International* 2006; 17: 91-8.
31. Cooper C, Westlake S, Harvey N, et al. Review: Developmental origins of osteoporotic fracture. *Osteoporosis International* 2006; 17: 337-47.
32. Moshfegh AJ, Rhodes DG, Baer DJ, et al. The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. *American Journal of Clinical Nutrition* 2008; 88: 324-32.
33. Garriguet D. Under-reporting of energy intake in the Canadian Community Health Survey. *Health Reports* 2008; 19(4): 37-45.
34. Tucker KL. Osteoporosis prevention and nutrition. *Current Osteoporosis Reports* 2009; 7: 111-7.
35. U.S. Department of Health and Human Services. *Bone Health and Osteoporosis: A Report of the Surgeon General*. Office of the Surgeon General Web site. Available at: http://www.surgeongeneral.gov. Accessed May 7, 2010